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(54) **SETTING COPY PERMISSIONS FOR TARGET DATA IN A COPY RELATIONSHIP**

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(52) **U.S. Cl.**
CPC ***G06F 11/1469*** (2013.01); ***G06F 3/065*** (2013.01); ***G06F 3/067*** (2013.01); ***G06F 3/0619*** (2013.01); ***G06F 11/1435*** (2013.01); ***G06F 11/1451*** (2013.01); ***G06F 11/1461*** (2013.01);
(Continued)

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USPC 711/100, 154, 162, 163, 170
See application file for complete search history.

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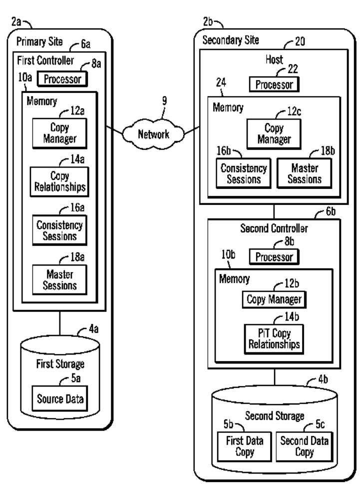
(57) **ABSTRACT**

Providing a computer program product, system, and method for setting copy permissions for target data in a copy relationship. Source data is copied from a first storage to a first data copy in a second storage. A request is received to copy requested data from the first data copy to a second data copy. The second copy operation is performed to copy the requested first data copy form the second storage to a second data copy in response to determining that the requested first data copy is not in the state that does not permit the copying. The request is denied in response to determining that the requested first data copy is in the state that does not permit copying.

11 Claims, 4 Drawing Sheets



(51) **Int. Cl.**

G06F 12/16	(2006.01)
G06F 3/06	(2006.01)
G06F 13/00	(2006.01)
G06F 11/20	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 11/1464*** (2013.01); ***G06F 12/16*** (2013.01); *G06F 11/2071* (2013.01); *G06F 2201/82* (2013.01); *G06F 2201/825* (2013.01); *G06F 2201/84* (2013.01)

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Preliminary Amendment filed May 8, 2015, pp. 10, for U.S. Appl. No. 14/708,130, filed May 8, 2015.

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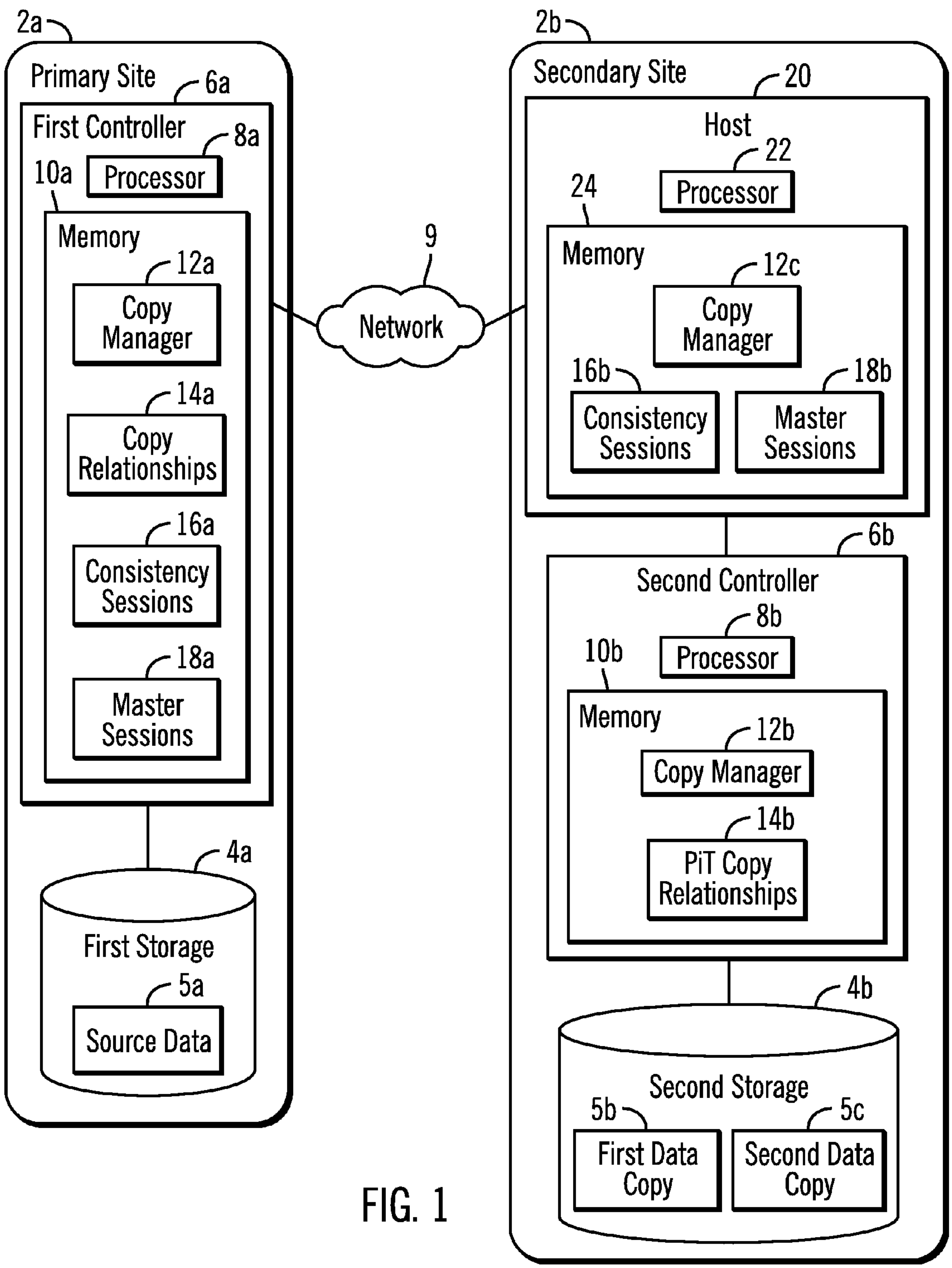
2a
Primary Site
6a
First Controller
8a
10a
Processor
Memory
12a
Copy Manager
14a
Copy Relationships
16a
Consistency Sessions
18a
Master Sessions
4a
First Storage
5a
Source Data
9
Network
2b
Secondary Site
20
Host
22
24
Processor
Memory
12c
Copy Manager
16b
Consistency Sessions
18b
Master Sessions
6b
Second Controller
8b
10b
Processor
Memory
12b
Copy Manager
14b
PiT Copy Relationships
4b
Second Storage
5b
5c
First Data Copy
Second Data Copy

FIG. 1

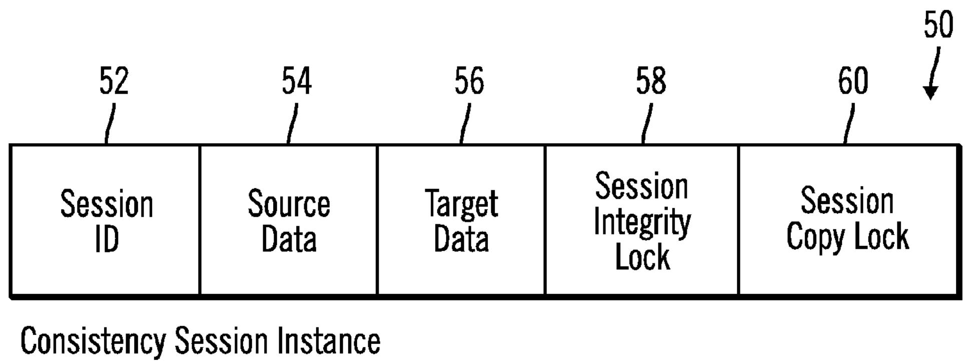
50
52
54
56
58
60
Session ID
Source Data
Target Data
Session Integrity Lock
Session Copy Lock
Consistency Session Instance

FIG. 2

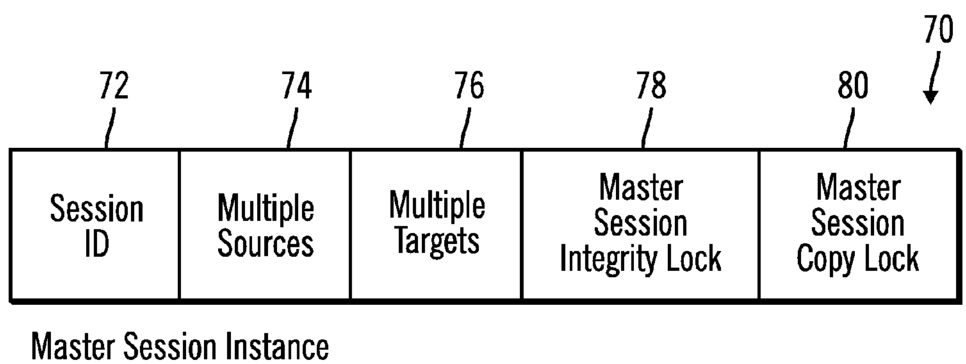
70
72
74
76
78
80
Session ID
Multiple Sources
Multiple Targets
Master Session Integrity Lock
Master Session Copy Lock
Master Session Instance

FIG. 3

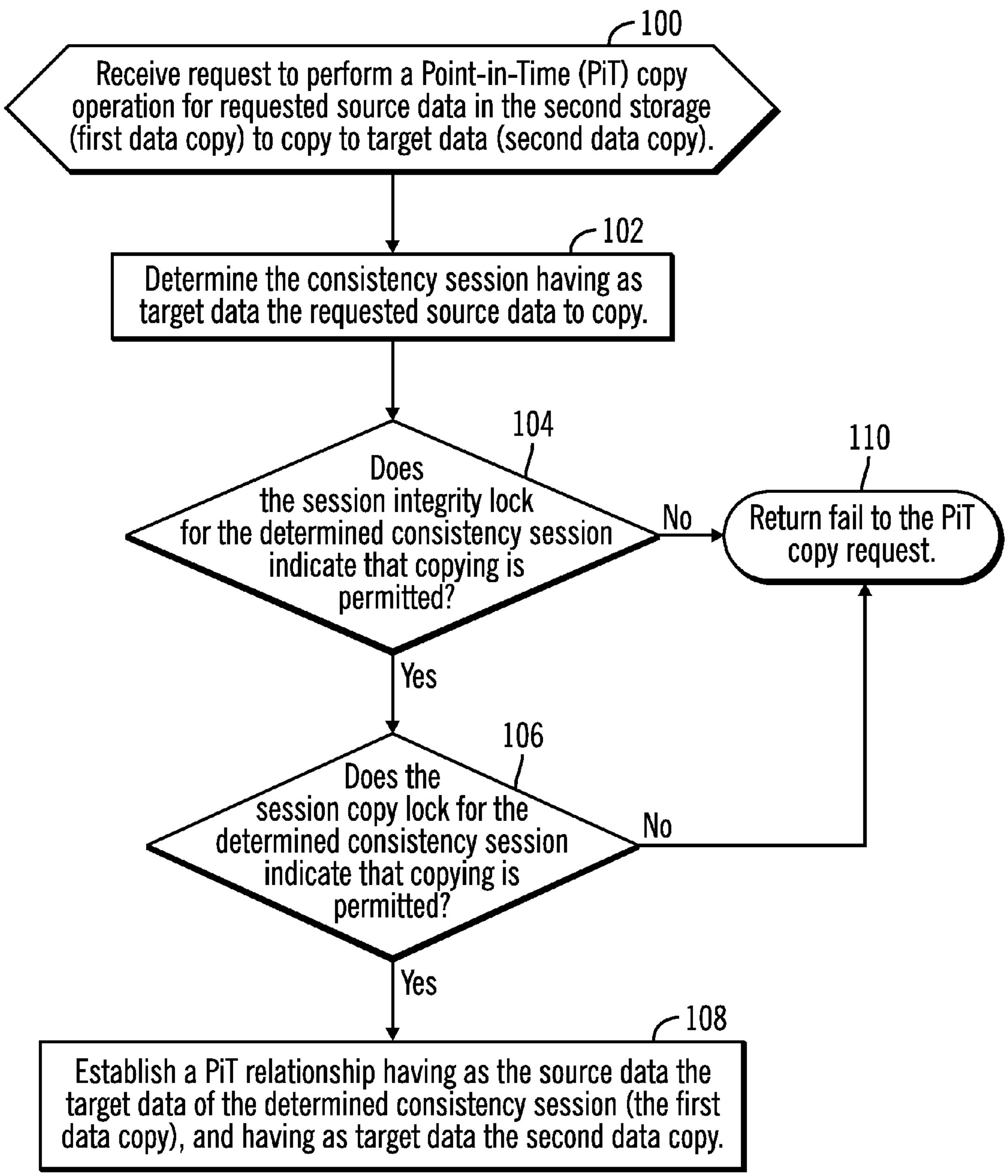
100
Receive request to perform a Point-in-Time (PiT) copy operation for requested source data in the second storage (first data copy) to copy to target data (second data copy).
102
Determine the consistency session having as target data the requested source data to copy.
104
Does the session integrity lock for the determined consistency session indicate that copying is permitted?
No
110
Return fail to the PiT copy request.
Yes
106
Does the session copy lock for the determined consistency session indicate that copying is permitted?
No
Yes
108
Establish a PiT relationship having as the source data the target data of the determined consistency session (the first data copy), and having as target data the second data copy.

FIG. 4

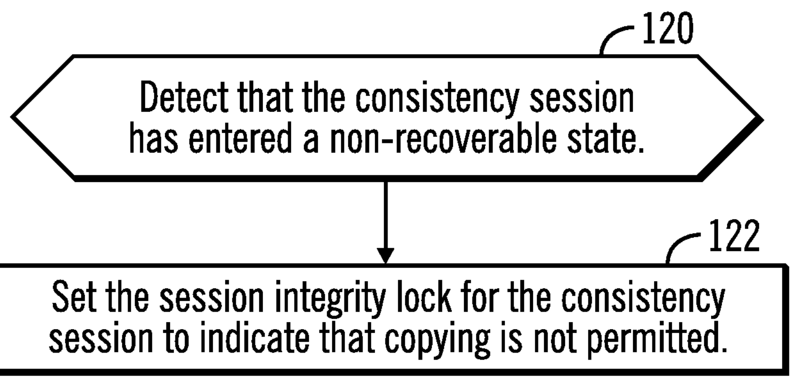

FIG. 5

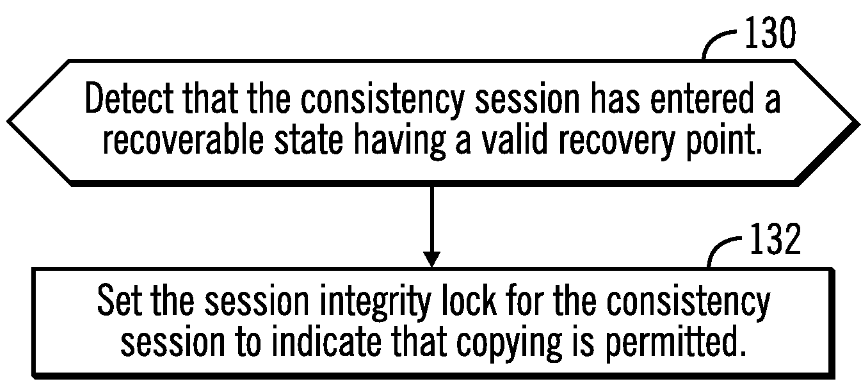

FIG. 6

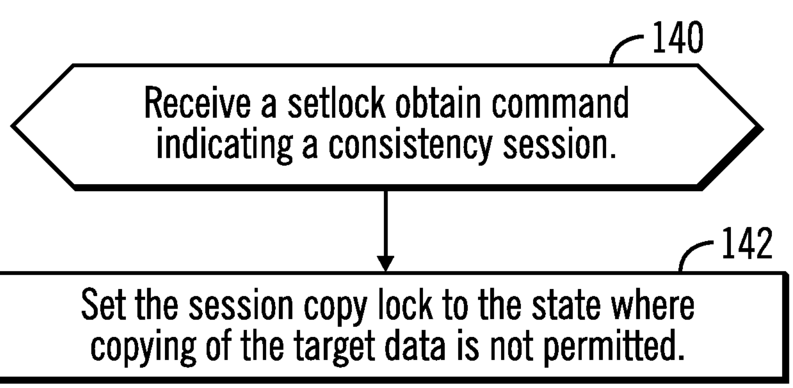

FIG. 7

SETTING COPY PERMISSIONS FOR TARGET DATA IN A COPY RELATIONSHIP

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 13/734,755, filed on Jan. 4, 2013, which application is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a computer program product, system, and method for setting copy permissions for target data in a copy relationship.

2. Description of the Related Art

In a storage environment, production volumes at a primary storage site may be copied to volumes in a secondary storage site to provide redundant copies of data. In the International Business Machine Corporation's ("IBM") z/OS® Global Mirror, data is asynchronously copied from the primary storage site to the secondary storage site. Data may be copied in consistency groups, such that copied data is consistent as of a point-in-time. In a consistency group, the order of dependent writes is preserved in the copying of the data. (z/OS is a registered trademark of IBM in the United States and other countries)

The target data at the secondary site, to which the source data at the primary storage site is copied, may be copied to a third copy at the secondary site using point-in-time ("PiT") copy techniques, such as the IBM FlashCopy® (FlashCopy is a registered trademark of IBM). In this way the target data in the copy relationship with the source data at the primary site becomes the source data for the PiT copy to the third copy. In other implementations, such as IBM Global Copy, the third copy may be in a third site.

There is a need in the art for improved techniques for managing the copy of the target data at the secondary site to an additional copy.

SUMMARY

Providing a computer program product, system, and method for setting copy permissions for target data in a copy relationship. A first copy operation copies source data from a first storage to a first data copy in a second storage. A request is received to perform a second copy operation to copy requested data from the first data copy in the second storage to a second data copy, wherein the requested data comprises the first data copy of the first copy operation. A determination is made as to whether the requested first data copy is in a state that does not permit copying in response to receiving the request. The second copy operation is performed to copy the requested first data copy form the second storage to a second data copy in response to determining that the requested first data copy is not in the state that does not permit the copying. The request is denied in response to determining that the requested first data copy is in the state that does not permit copying.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an embodiment of a storage replication environment.

FIG. **2** illustrates an embodiment of a consistency session instance.

FIG. **3** illustrates an embodiment of a master session instance.

FIG. **4** illustrates an embodiment of operations to process a request to perform a PiT copy operation.

FIG. **5** illustrates an embodiment of operations to perform when detecting that the consistency session has entered a non-recoverable state.

FIG. **6** illustrates an embodiment of operations to perform when detecting that the consistency session has entered a recoverable state.

FIG. **7** illustrates an embodiment of operations to process a setlock obtain command.

DETAILED DESCRIPTION

Described embodiments provide techniques for indicating that target data or a first data copy, in a second storage in a copy relationship, e.g., consistency session, with source data in a first storage is in a state that does not permit copying, such as using the target data (first data copy), in the consistency session as source data to copy to a second data copy. A session integrity lock for the consistency session may be set to indicate that the first data copy, e.g., target data, in the consistency session is in a state that does not permit copying upon detecting that the source-target data in the copy relationship is not at a recoverable point. Further, a user settable session copy lock may allow a user or program to indicate that the first data copy in a consistency session is not to be copied independent of the session integrity lock. This allows the user to specify that a first data copy in a copy relationship is not to be copied to a second data copy if the user is utilizing the data in the consistency session in the first data copy.

FIG. **1** illustrates an embodiment of a data replication environment having a primary site **2***a* and a secondary site **2***b*, where source data **5***a* maintained in a first storage **4***a* in the primary site **2***a* may be replicated to a target first data copy **5***b* in a second storage **4***b* using a first copy operation, where data is synchronized from the first storage **4***a* to the second storage **4***b*. The first data copy **5***b* in the second storage **4***b* may be copied to a second data copy **5***c* in the second storage **4***b* as part of a second copy operation, such as a point-in-time copy operation, e.g., FlashCopy, snapshot, etc. The data **5***a*, **5***b*, **5***c* may comprise volumes or other units of data. The sites **2***a*, **2***b* may further include first **6***a* and second **6***b* controllers, respectively, to manage Input/Output (I/O) access to the corresponding storages **4***a*, **4***b*. The secondary site **2***b* further includes a host **20** to manage the copying of the source data **5***a* to the first data copy **5***b*. The second storage controller **6***b* manages the copying of data from the first data copy **5***b* to the second data copy **5***c*. The sites **2***a*, **2***b* may be in a same physical or geographical location and/or in different geographical locations. Further, the sites **2***a*, **2***b* may be implemented in a same computer node or different computer nodes.

Each controller **6***a*, **6***b* includes a processor **8***a*, **8***b* and a memory **10***a*, **10***b* including a copy manager **12***a*, **12***b*. Hosts (not shown) may direct read and write requests to the first controller **6***a* to access the source **5***a* data in the first storage **4***a*. A host write to the source data **5***a* in the first storage **4***a* in a copy relationship, such as a consistency session, may result in the copying of the update data to the first data copy **5***b*, e.g., target data, in the second storage **4***b*. The controllers **6***a*, **6***b* and host **20** may communicate over a network **9**.

The host **20** includes a processor **22** and a memory **24** into which programs are loaded for the processor **22** to execute, including a copy manager **12***c*.

The copy manager **12***a* at the first controller **6***a* may copy the source data **5***a* from the first storage **4***a* to the first data copy **5**a in the second storage **4**b as specified in a copy relationship **14**a. A copy relationship **14**a may identify source volumes as the source data **5**a in the first storage **4**a to copy to target volumes, e.g., first data copy **5**b, in the second storage **4**b. The data to copy in the copy relationship **14**a may be part of a consistency session or consistency group, such that data is copied in a manner to maintain consistency across all dependent data, so that the order of dependent writes is preserved to make the data consistent as of a point-in-time.

In one embodiment, the host **20** copy manager **12**c manages the copying of the source data **5**a to the first data copy **5**b at the secondary site **2**b. The copy managers **12**a, **12**c maintain consistency sessions **16**a, **16**b having information on consistency sessions having source data **5**a in the first storage **4**a to copy to the first data copy **5**b in the second storage **4**b as part of a copy relationship **14**a, such that updates to the source data **5**a in the first storage **4**a are copied to the first data copy **5**b, e.g., target data, in the second storage **4**b and master sessions **18**a, **18**b having information on master sessions.

The copy manager **12**a maintains consistency session **16**a information indicating data in the consistency session that needs to be copied, which data may be part of an initial copy of all the data in the consistency session **16**a and updated data, so that the updated data is copied to the first data copy **5**b in the second storage **4**b. The copy manager **12**a communicates with the copy manager **12**c in the host **24** to copy data as part of a consistency session **16**a, **16**b. Updates to the source data **5**a are stored in the memory **10**a. The copy manager **12**a asynchronously offloads the updates from the memory **10**a through the network **9** to the copy manager **12**c in the host **20**. The copy manager **12**c maintains consistency session information **16**b to write the updates to the first data copy **5**b with consistency via the second controller **6**b. Write updates to the first storage **4**a from a connected host (not shown) do not have to wait for the offload process to the copy manager **12**c to complete.

The copy manager **12**b in the second storage controller **6**b maintains PiT copy relationship information **14**b providing information on PiT copies from the first data copy **5**b to the second data copy **5**c in the second storage **4**b, so that data copied from the first storage **4**a to the second storage **4**b is further copied as part of a PiT copy operation to the second data copy **5**c.

The copy manager **12**b in the second controller **6**b may implement a PiT program such as IBM FlashCopy, snapshot, and other PiT programs, to perform a PiT copy operation between the first data copy **5**b and the second data copy **5**c in the third storage **4**b. The copy manager **12**b maintains the PiT copy relationships **14**b identifying the source data in the first data copy **5**b in the second storage **4**b subject to being copied as part of a PiT copy to identified corresponding target data in the second data copy **5**c. The PiT copy relationship **14**b may further include a PiT bitmap indicating the source data, e.g., the first data copy **5**b in the second storage **4**b, that has been copied to the second data copy **5**c in the second storage **4**b, so that the data as of the point-in-time comprises the first data copy **5**b in the second storage **4**b and the PiT source data copied to the second data copy **5**c before being updated. The PiT copy relationship **14**b may be configured with a background copy operation to copy all source data in the relationship in the first data copy **5**b to the second data copy **5**c in the second storage **4**b in the background. When source data is copied as part of the background operation, the bit for that copied source data in the PiT bitmap is updated to indicate that the sourced data as of the point-in-time resides in the target data in the third storage **4**c.

In an alternative embodiment, the second data copy **5**c may be at a third storage site. If the second data copy **5**c is at a third storage site, then the copy manager **12**b may have to switch to synchronous copy and suspend the data copy process to the second data copy **5**c.

The copy managers **12**a, **12**b, **12**c are shown in FIG. **1** as program code loaded into the memories **10**a **10**b, and **24** and executed by the processors **8**a, **8**b, **22**, respectively. Alternatively, some or all of the functions of these programs may be implemented in hardware devices in the controllers **6**a, **6**b and host **20**, such as in Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGA), etc.

The memories **10**a, **10**b **24** may comprise one or more volatile or non-volatile storage devices, such as a Dynamic Random Access Memory (DRAM), Random Access Memory (RAM) or a non-volatile memory, e.g., battery backed-up Random Access Memory (RAM), static RAM (SRAM), solid state storage devices (SSDs), etc.

The storages **4**a, **4**b may store tracks in a Redundant Array of Independent Disks (RAID) configuration where strides of tracks are written across multiple storage devices comprising the storages **4**a, **4**b. Strides comprise tracks written across disks in a RAID rank, where a stride of track includes data and parity information calculated form the data in the stride striped across the storage devices. A RAID rank comprises a group of storage devices configured to work as a RAID set, such that the stride of tracks, including data and parity tracks, are striped across the storage devices in the RAID rank. The storages **4**a, **4**b may include one or more configured RAID ranks.

The storages **4**a, **4**b may each comprise one or more storage devices known in the art, such as interconnected storage devices, where the storage devices may comprise hard disk drives, solid state storage device (SSD) comprised of solid state electronics, such as a EEPROM (Electrically Erasable Programmable Read-Only Memory), flash memory, flash disk, Random Access Memory (RAM) drive, storage-class memory (SCM), etc., magnetic storage disk, optical disk, tape, etc. The network **9** may comprise a network such as a Local Area Network (LAN), Storage Area Network (SAN), Wide Area Network (WAN), peer-to-peer network, wireless network, etc. Further the network **9** may be separated into separate networks between the controller **6**a and the host **20**.

FIG. **2** illustrates a consistency session instance **50** maintained for one consistency session in the consistency sessions **16**a, **16**b. The consistency sessions **16**a, **16**b may include multiple consistency session instances **50**, one for each consistency session established between source data in the first storage **4**a to copy to target data in the second storage **4**b. The consistency session instance **50** includes a session identifier (ID) **52**, source data **54**, such as one or more volumes in the source data **5**a in the first storage **4**b; target data **54**, e.g., first data copy **5**b, such as one or more volumes in the second storage **4**b to which the source data **54** is copied; a session integrity lock **58** indicating whether the target data **56**, e.g., first data copy **5**b, in the consistency session **52** is at a valid recovery point, such as consistent as of a point-in-time; and a user settable session copy lock **60** indicating that target data **56** in the first data copy **4**b for the session **50** may not be used as source data for a copy operation, such as a PiT copy operation to the second data copy **5**c. The source **54** and target **56** data for a session instance **50** may comprise one or more volumes in the storages **4**a, **4**b, a set of extents or blocks, or other units of data.

The session integrity lock **58** may be set to indicate that the data in the consistency session is not at a valid recovery point if the copy manager **12**c detects one of: that there is an ongoing synchronization or resynchronization operation between the source data **54**, e.g., source data **5***a*, and target data **56**, e.g., first data copy **5***b*, for the session **52**; that there has been a suspension of the disk or storage having the source data **54** and target data **56**; that a pair of source **54** and target **56** disks have been deleted; and that a request to move a consistency session to a different session is initiated.

The session copy lock **60** indicates whether a copy operation, such as a PiT copy, may be performed with respect to a target of the PiT copy, such as the third storage **4***c*. The copy manager **12***c* may implement a setlock command with a parameter identifying the consistency session **50** to which the setlock command applies and a parameter indicating whether the command is to obtain or release the session copy lock **60**. A user or program would submit a setlock obtain command for a specified consistency session **50** to set the session copy lock **60** for the specified session to prevent the target data **56** in the specified session **50** from being copied.

A user or program would submit a setlock release command for a specified consistency session to set the session copy lock **60** for the specified session to allow the target data **56** in the specified session **50** to be copied as part of a copy operation. A user or program may want to use the setlock command to prevent copying of target data in a consistency session to the second data copy **5***c* according to the PiT copy relationship for a specific activity, such as testing or dumping to tape. The user may want to stop the copying operation to prevent the second data copy **5***c* from being overwritten or accidently withdrawn until the activity has completed.

In this way, if the session copy lock **60** is set, the copy manager **12***b* does not allow PiT copies to be taken of the session target data **56**, e.g., first data copy **5***b*, in the second storage **4***b* to the second data copy **5***c*. When the session copy lock **60** is set, the copy manager **12***b* may fail any request to establish a PiT copy between the target data **56** in the second storage **4***b*, e.g., first data copy **5***b*, and the second data copy **5***c*, or withdraw an existing PiT copy. The session copy lock **60** may prevent the PiT copy operation even if the session integrity lock **58** indicates that the source data at the second storage **4***b* is at a valid recovery point.

FIG. **3** illustrates a master session instance **70** maintained for one consistency session. The master sessions **18***a*, **18***b* may include a master session instance **70** for each master session established including the first **4***a* and second **4***b* storages. The master session instance **70** includes a master session identifier (ID) **72**, multiple sources **74**, and multiple targets **76**, such that the multiple sources **74** and multiple targets **76** indicate multiple source-target pairs for copying in different storage sites that are part of the master session. The master session instance **70** further includes a master session integrity lock **78** indicating whether the data in the consistency session **52** for all the source **74** and target **76** pairs is at a valid recovery point, such as consistent as of a point-in-time and a user settable master session copy lock **80** indicating that target data in the targets **76** may not be subject to a copy operation, such as a PiT copy operation.

With a master data session, a master storage controller signals the source storage controllers, including the first controller **6***a*, to copy their data to the corresponding target storages **76**, including the second storage **4***b*. The master consistency session is consistent as of a point-in-time, when all dependent writes across all the source storages **74** are copied in order to the target storages **76**, so consistency is maintained among all source-target storage pairs at different sites in the master session. The master session integrity lock **78** indicates whether the data in all the source-target storage pairs is consistent.

FIG. **4** illustrates an embodiment of operations performed by the copy manager **12***b*, in the storage controller **6***b*, to perform a PiT copy operation for target data **56** in a consistency session, e.g., the first data copy **5***b*, in the second storage **4***b*, to the second data copy **5***c* in the second storage **4***b*. The request may be directed to copy target data **56** in the second storage **4***b* that is in a consistency session **50** or master consistency session **80** to the second data copy **5***c*, such that the target data **56**, first data copy **5***b*, in the consistency session is the source data for the new requested PiT copy operation. Upon receiving the request (at block **100**) the copy manager **12***b* determines (at block **102**) the consistency session **16***b* having as target data **56** the requested source data to copy. The copy manager **12***b* may determine the consistency session **16***b* and related session information, such as, but not limited to, the session integrity lock **58**, session copy lock **60**, etc., by communicating with the host copy manager **12***c*, accessing a copy of the consistency session **16***b* at the host **20** or in the storage **4***b*, or maintaining a local copy of the consistency session **16***b* information. If (at block **104**) the session integrity lock **58** for the determined consistency session, whose target data **56**, e.g., first data copy **5***b*, is subject to the PiT copy operation, then this indicates that copying is permitted, i.e., the target data **56**, e.g., first data copy **5***b*, is at a valid recovery point, then a further determination is made (at block **106**) of whether the user settable storage copy lock **60** for the consistency session indicates that copying is permitted. If both the session integrity lock **58** and the session copy lock **60** indicate that copying is permitted, then the copy manager **12***b* establishes (at block **108**) a PiT copy relationship **20** for the target data **56**, e.g., first data copy **5***b*, in the consistency session **50** to be the source data for the requested PiT copy operation and the requested target data, e.g., second data copy data **5***c*, in the second storage **4***b* to be the target data of the PiT copy. If either the session integrity lock **58** or the session copy lock **60** indicate that copying is not permitted, then fail is returned (at block **110**) to the PIT copy request.

The operations of FIG. **4** are described with respect to a PiT copy operation attempted with respect to a first data copy **5***b* in the second storage **4***b* that is target data **56** in a consistency session receiving source data **54** from the first storage **4***a*. In a further embodiment, the consistency session target data **56**, first data copy **5***b*, in the second storage **4***b* subject to the PiT copy operation may comprise target data that is one of multiple targets **76** in a master session **76**, such that the master session integrity lock **78** does not permit copying until data is recoverable and consistent across all source-target pairs, including the first storage **4***a* and the second storage **4***b*, in the master session.

The requested PiT copy operation of FIG. **4** may comprise an operation to establish a point-in-time relationship, suspend a point-in-time copy relationship, and withdraw a point-in-time copy relationship.

Although the operations of FIG. **4** were described with respect to a PiT copy operation, the copy operation from the second storage **4***b* to the third storage **4***c* may comprise a different type of copy operation than a PiT copy, such as a full copy of all the data.

FIG. **5** illustrates an embodiment of operations performed by the copy manager **12***c* in the host **20** to set the session integrity lock **58** for data in a consistency session. Upon detecting (at block **120**) that a consistency session has entered a non-recoverable state, the session integrity lock **58** is set (at block **122**) to indicate that copying is not permitted. As mentioned, a non-recoverable state may be detected when a synchronization or resynchronization operation is ongoing between the source data **54** in the first storage **2***a* and target data **56** in the second storage **2***b* or when an operator explicitly sets the lock **58**.

FIG. **6** illustrates an embodiment of operations performed by the copy manager **12***c* to set the session integrity lock **58** for data in a consistency session. Upon detecting (at block **130**) that a consistency session has entered a recoverable state having a valid recovery point, the session integrity lock **58** is set (at block **132**) to indicate that copying is permitted. A valid recovery point that results in the setting of the session integrity lock **58** to indicate that copying is permitted may occur upon detecting that a previously initiated synchronization or resynchronization operation has completed for a session, that an operator explicitly releases the session integrity lock **56**, or that a locked session is removed from the configuration.

FIG. **7** illustrates an embodiment of operations performed by the copy manager **12***c* to set the session copy lock **60** to a state indicating that copying of the target data **56**, e.g., first data copy **5***b*, in the session is not permitted. Upon receiving (at block **140**) a setlock obtain command specifying a consistency session, the copy manager **12***c* sets (at block **142**) the session copy lock **60** for the specified consistency session to indicate that the target data **56**, e.g., first data copy **5***b*, is in the state that does not permit copying.

A setlock release command specifying a consistency session may be submitted by a user or program to cause the copy manager **12***c* to set the session copy lock **60** for the specified consistency session to indicate that copying of the target data **56** is permitted.

In the described embodiments, separate copy managers **12***b* and **12***c* are shown at the secondary site **2***b* in a storage controller **6***b* and host **20**, respectively. In alternative embodiments, the functions of the copy managers **12***b* and **12***c* may be implemented in one or more programs at the secondary site **20** as a single program or additional programs in either the host **20**, the second controller **6***b* and/or additional systems.

The described embodiments provide techniques for indicating that target data in a consistency session is not permitted to be used as source data in an additional PiT copy operation to target data in the second data copy **5***c*. A session integrity lock is used to automatically indicate that target data, first data copy **5***b*, is in the state that does not permit copying if the source **5***a* and target **5***b* data in the consistency session is not at a recoverable point. A session integrity lock is settable by a user to indicate that target data in the consistency session is not to be copied such as in the case that the user is performing activity with respect to a copy of the target data in the consistency session maintained in a PiT copy relationship in the third storage.

The described operations may be implemented as a method, apparatus or computer program product using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof. Accordingly, aspects of the embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, microcode, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, aspects of the embodiments may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

Any combination of one or more computer readable medium(s) may be utilized. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

Program code embodied on a computer readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

Computer program code for carrying out operations for aspects of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

Aspects of the present invention are described above with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

The terms "an embodiment", "embodiment", "embodiments", "the embodiment", "the embodiments", "one or more embodiments", "some embodiments", and "one embodiment" mean "one or more (but not all) embodiments of the present invention(s)" unless expressly specified otherwise.

The terms "including", "comprising", "having" and variations thereof mean "including but not limited to", unless expressly specified otherwise.

The enumerated listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise.

The terms "a", "an" and "the" mean "one or more", unless expressly specified otherwise.

Devices that are in communication with each other need not be in continuous communication with each other, unless expressly specified otherwise. In addition, devices that are in communication with each other may communicate directly or indirectly through one or more intermediaries.

A description of an embodiment with several components in communication with each other does not imply that all such components are required. On the contrary a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention.

Further, although process steps, method steps, algorithms or the like may be described in a sequential order, such processes, methods and algorithms may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of processes described herein may be performed in any order practical. Further, some steps may be performed simultaneously.

When a single device or article is described herein, it will be readily apparent that more than one device/article (whether or not they cooperate) may be used in place of a single device/article. Similarly, where more than one device or article is described herein (whether or not they cooperate), it will be readily apparent that a single device/article may be used in place of the more than one device or article or a different number of devices/articles may be used instead of the shown number of devices or programs. The functionality and/or the features of a device may be alternatively embodied by one or more other devices which are not explicitly described as having such functionality/features. Thus, other embodiments of the present invention need not include the device itself.

The illustrated operations of the figures show certain events occurring in a certain order. In alternative embodiments, certain operations may be performed in a different order, modified or removed. Moreover, steps may be added to the above described logic and still conform to the described embodiments. Further, operations described herein may occur sequentially or certain operations may be processed in parallel. Yet further, operations may be performed by a single processing unit or by distributed processing units.

The foregoing description of various embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto. The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims herein after appended.

What is claimed is:

1. A method for copying data from a first storage to a second storage, comprising:

performing a first copy operation to copy source data from the first storage to a first data copy in the second storage;

receiving a request to perform a second copy operation to copy requested data from the first data copy in the second storage to a second data copy, wherein the requested data comprises the first data copy of the first copy operation;

determining whether the first data copy is in a state that does not permit copying in response to receiving the request;

performing the second copy operation to copy the requested data from the first data copy in the second storage to a second data copy in response to determining that the first data copy is not in the state that does not permit the copying; and

denying the request in response to determining that the first data copy is in the state that does not permit copying.

2. The method of claim **1**, wherein the determining that the first data copy is in the state that does not permit copying comprises:

determining whether the first data copy provides a valid recovery point for the source data, wherein the first data copy is in the state that does not permit copying in response to determining that the first data copy does not provide a valid recovery point.

3. The method of claim **1**, wherein the source data and the first data copy are in a consistency session, further comprising:

maintaining a session integrity lock for the consistency session, wherein the session integrity lock is set to indicate that the first data copy in the consistency session is in the state that does not permit copying when the data in the consistency session has entered a non-recoverable state, and wherein the determining whether the first data copy is in the state that does not permit copying comprises determining whether the session integrity lock indicates that the first data copy is in the state that does not permit copying.

4. The method of claim **3**, further comprising:

determining whether a synchronization or resynchronization operation is being performed or has completed for the consistency session;

setting the session integrity lock for the consistency session to the state that does not permit copying in response to determining that the synchronization or resynchronization operation is being performed for the consistency session; and

setting the session integrity lock for the consistency session to the state that permits copying in response to determining that the synchronization or resynchronization operation being performed for the consistency session has completed.

5. The method of claim **3**, further comprising:

maintaining a session copy lock for the consistency session indicating whether copying is permitted for the first data copy in the consistency session;

receiving an obtain command with respect to the consistency session;

setting the session copy lock to indicate that copying is not permitted for the first data copy in the consistency session in response to receiving the obtain command;

receiving a release command with respect to the consistency session;

setting the session copy lock to indicate that copying is permitted for the first data copy in the consistency session in response to receiving the release command.

6. The method of claim **5**, further comprising:

determining whether the session copy lock for the consistency session indicates that copying is permitted in response to receiving the request, wherein the first data copy is determined to be in the state that does not permit copying in response to determining that the session integrity lock indicates the state that does not permit copying or determining that the session copy lock indicates that copying is not permitted.

7. The method of claim **6**, wherein the obtain and release commands are sent by a user at a user interface, and wherein the first data copy is in the state that does not permit copying in response to determining that the first data copy is not at a valid recovery point, and wherein the session copy lock is capable of preventing the second copy operation when the requested data is at the valid recovery point.

8. The method of claim **3**, wherein the copying of the source data to the first data copy in the consistency session is managed by a first controller managing the first storage and a host coupled to a second controller managing the second storage, and wherein the second copy operation to copy the first data copy to the second data copy is managed by the second controller.

9. The method of claim **3**, wherein there are a plurality of sessions established between the first and the second storage managed as a master session, wherein there is a master session integrity lock to provide overall consistency across all the sessions in the master session, wherein the determining whether the requested data is in the state that does not permit copying comprises determining whether the master session integrity lock indicates that target data including the requested data is in the state that does not permit copying.

10. The method of claim **1**, wherein the first copy operation continuously transmits updated data that needs to be copied from the source data in the first storage to the first data copy in the second storage, and wherein the second copy operation comprises a point-in-time copy operation at the second storage.

11. The method of claim **1**, wherein the second copy operation copies the first data copy to the second data copy in a third storage.

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